



Forest Health Protection

Pacific Southwest Region

Northeastern California Shared Service Area

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To: District Ranger, Big Valley/Doublehead Ranger District, Modoc National Forest

Subject: Considerations for fire-injured tree harvest and hazard tree abatement within the 2015 Frog Fire, Modoc National Forest (FHP Report NE15-11)

At the request of John Landoski, District Cultivist, Big Valley Ranger District, Danny Cluck, Forest Health Protection (FHP) Entomologist, visited the Frog Fire with district staff on October 7, 2015. The objective of this visit was to evaluate the levels of fire injury to conifers, note any insect activity and discuss variables that should be considered when developing fire-injured tree and hazard tree marking guidelines. Recommendations provided in this report will assist in the formulation of silvicultural prescriptions aimed at removing a portion of the fire-injured trees including the abatement of roadside hazard trees.

Description of the project area

The 4,863 acre Frog Fire, located ~25 miles north of McArthur, CA, started on July 30, 2015 and was contained August 8, 2015 (41.414008N and 121.390722E). The elevation ranges from 4,300 – 4,500 feet with annual precipitation ranging between 15 and 30 inches. Forest species composition is primarily ponderosa pine (*Pinus ponderosa*) with scattered incense cedar (*Calocedrus decurrens*), white fir (*Abies concolor*) and western juniper (*Juniperus occidentalis*).

General observations

Observations were made at a number of locations representing different vegetation burn severities.

- Trees with only partial crown scorching had minimal insect activity. Most of this was single red turpentine beetle attacks at the base where cambium injury was likely present.
- Trees that were killed during the fire and had foliage completely consumed were under heavy infestation by woodboring beetles. This activity appeared to be concentrated in the smaller diameter pines (<14" dbh) at this early stage based on the presence of boring dust. The timing of the fire coinciding within the peak flight period for many wood boring beetle

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species suggests that this condition is widespread within the fire perimeter and will become more apparent over time.

- A few trees that are within striking distance of the road will likely meet the 1/2 cambium kill criteria, indicating high failure potential, as outlined in the R5 hazard tree guidelines (Angwin et al 2012). Most trees that meet this guideline are those that had excessive coarse woody debris, especially large logs, consumed at the base of the bole.

Pre-fire bark beetle activity

FHP aerial detection surveys mapped mortality within and adjacent to the Frog Fire area in 2014 and 2015. In 2014, western pine beetle (*Dendroctonus brevicornis*, and possibly mountain pine beetle (*Dendroctonus ponderosae*) killed ponderosa pines in 35 locations spread across the fire area as well as adjacent areas (within 1.5 miles). This mortality was mapped as single trees and small groups of up to 8 trees/acre. Approximately 5 miles to the north, south and west, larger areas of ponderosa mortality were mapped (271 acres w/1356 dead trees, 331 acres w/1658 dead trees, 413 acres w/826 dead trees)(Figure 1). In 2015, mortality increased considerably within and adjacent to the Frog Fire. Large areas with elevated levels of white fir and ponderosa pine mortality were mapped throughout the entire area (Figure 2) just prior to the fire.



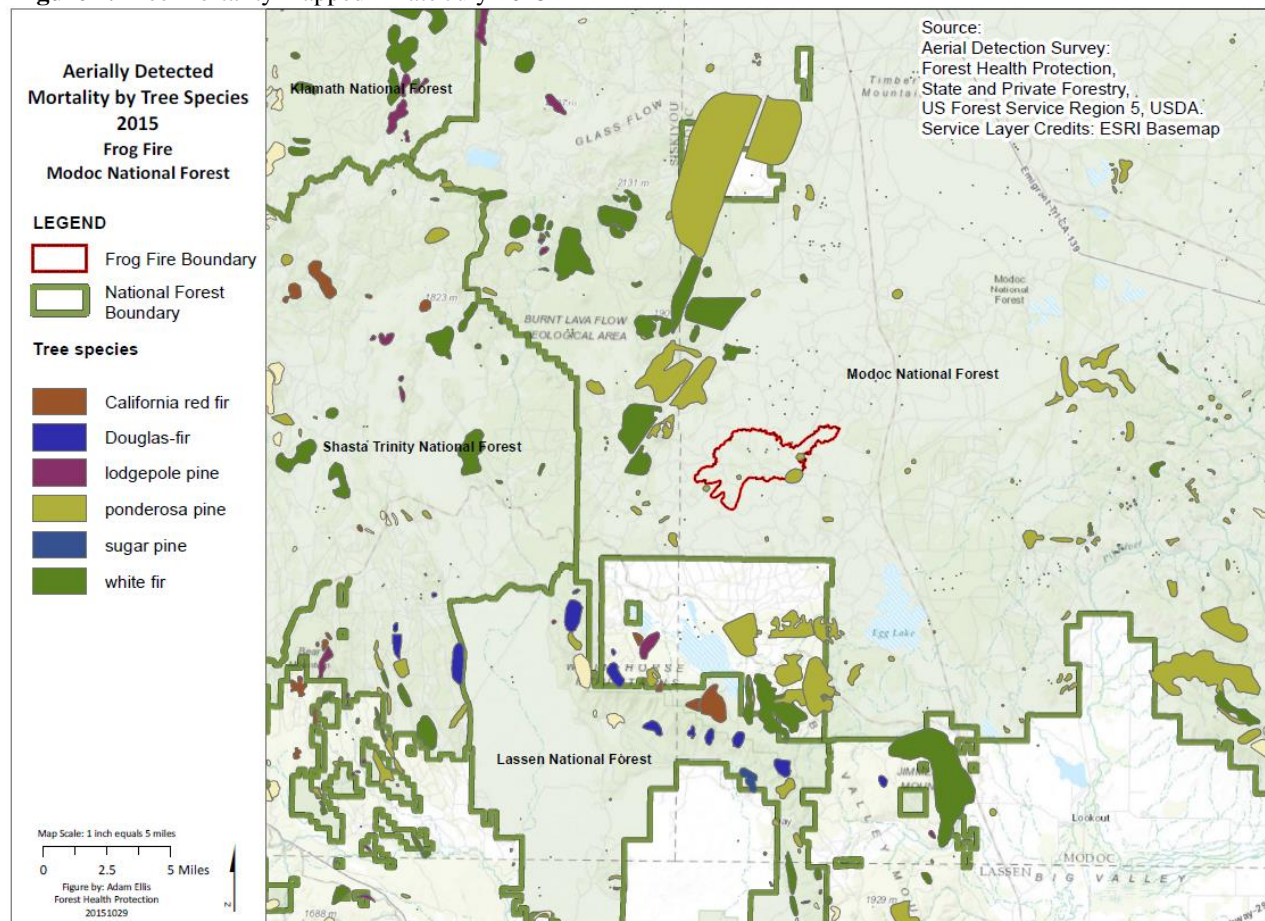
Figure 1. Example of ponderosa pine mortality observed in 2014 near the Frog Fire area.

Post-fire bark and woodboring beetle activity

The amount of post-fire insect activity and the resulting tree mortality depends on many factors such as the timing of the fire, the level of insect activity in the area prior to the fire, and stand characteristics. Fire-injured trees are stressed trees and the available soil moisture (pre- and post-fire) can also play a significant role in post-fire mortality. For the Frog Fire, most bark beetle activity in fire-injured trees will begin in the spring of 2016 and continue for 3 to 5 years. High levels of mountain pine beetle and western pine beetle activity should be expected in fire-injured ponderosa pine due to the elevated level of pre-fire tree mortality caused by these species. Existing bark beetle populations combined with the high number of fire-injured trees and the continuing extreme to exceptional drought conditions (US Drought Monitor 2015: Figure 3) will likely lead to major increases in bark beetle/fire-caused tree mortality over the next two years.

The level of fire-injury on an individual tree plays a role in post-fire insect activity. Fire-injured trees can be placed into three categories: 1) those killed outright or injured so severely that they will soon die, 2) those that are lightly injured and should survive, and 3) those in between, the moderately injured trees. Bark beetles will attack trees in all three categories but successful brood production will only occur in trees with moist cambium. Trees in category one typically do not have enough moist cambium after the fire or if they do, it will become either resin soaked or dry out before beetles can complete their development. Bark beetles attack these types of trees at lower

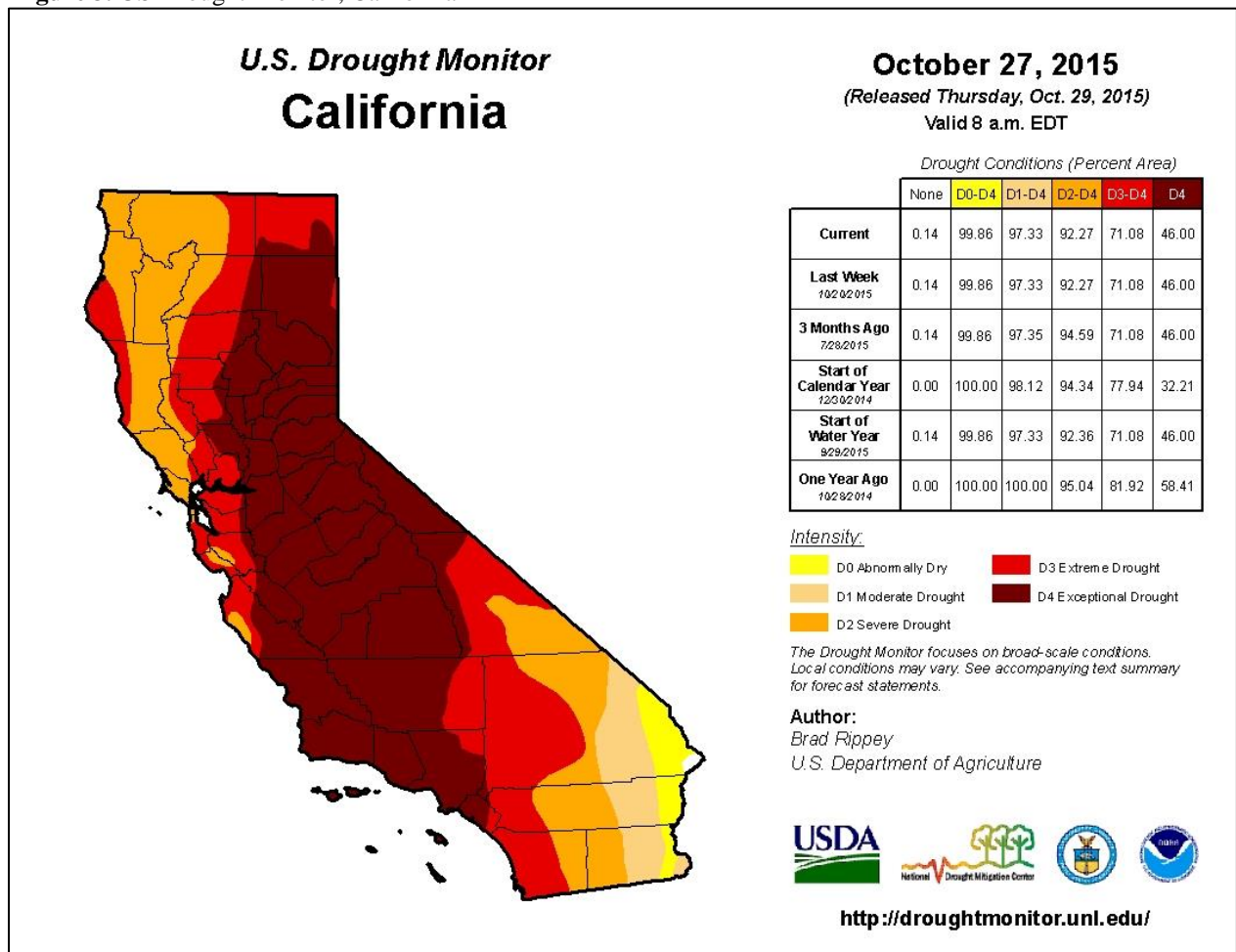
Figure 2. Tree mortality mapped in late July 2015



rates and also experience extreme competition from woodboring beetle larvae, reducing reproductive success. Trees in category two provide the highest level of suitable cambium for bark beetles but typically are not injured to the extent that their defenses are compromised. These trees still have the ability to pitch out beetles as they attack, or more often, are avoided by bark beetles altogether. However, based on the current extreme/exceptional drought conditions, and increased bark beetle activity throughout the Frog Fire area, the likelihood of lightly fire-injured trees being attacked by bark beetles is greatly increased relative to more normal post-fire conditions. The highest level of bark beetle attacks are likely to occur on trees in category three, the moderately injured trees. These trees will have moderate to high levels of crown scorch and cambium injury that compromise their defense systems, putting them at a higher probability of mortality. These trees provide ideal habitat for bark beetles for several years post-fire, especially if cambium injuries are concentrated on the lower bole or at the root collar.

The level of woodboring beetle activity in fire-killed trees will become even more apparent in late winter 2016 when woodpeckers begin boring into bark to feed on larvae. Woodboring beetles are likely to attack and successfully reproduce in both moderate and severely fire-injured trees as well as trees killed outright by the fire. Trees that had crowns completely consumed (blackened) are typically the first to be attacked, some within days of the fire. Wood borers will also attack trees that had crowns completely scorched but not consumed (red needles remaining) but initially at a lower intensity than blackened trees. Tree diameter also plays a role as initial attacks tend to be

Figure 3. US Drought Monitor, California



concentrated on smaller diameter trees and the tops of larger diameter trees and then increase and spread into the lower boles of larger diameter trees. Wood borers are not a threat to healthy trees within or adjacent to the burned areas.

The level of wood borer activity and the amount of deterioration to trees designated for harvest can also vary by tree species and size, timing of fire-injury, and by geographic location. For example, among the fires of 2012, the Reading Fire (Lassen NF) had extremely high levels of wood borer activity and associated deterioration of harvest trees one year post-fire while the Barry Point Fire (Modoc NF) and the Chips Fire (Lassen/Plumas NF) had significantly less activity and deterioration over the same timeframe. All of these fires burned in late-July through August. The Reading Fire burned in close proximity to the 2009 Sugarloaf fire (11,269 acres), which may be a partial explanation for the high level of wood borer activity observed within the first post-fire year.

Economic Losses and Potential Hazards Caused by Staining and Decay Fungi

Significant degrade and value losses are highly likely if fire-injured trees proposed for harvest are not removed promptly. Nearly all of the beetles previously discussed carry spores of staining and/or decay fungi that immediately begin to invade sapwood (Figure 4). Blue stain, although not a

source of structural degrade, can dramatically reduce the economic value of pine species. Blue stain spreads rapidly into the sapwood and by the end of one year can typically be found in nearly all dead and dying pines. A FHP monitoring study (Eglitis 2006) of 84 fire-killed ponderosa pines in central Oregon found blue stain in 100% of the first 16.5 foot bole sections and in 58% of the second 16.5 foot sections of sampled trees one year post-fire. At the end of two years, 92% of sampled trees had blue stain throughout the entire bole. The occurrence



Figure 5. Green fire-injured white fir failure five years post-fire.

of blue stain within the Frog Fire is not likely to increase significantly until temperatures warm again next spring/summer and additional bark and wood-boring beetle activity carries staining fungi to more trees. Decay fungi that are introduced typically do not cause significant degrade until after the first post-fire year, with smaller diameter trees decaying faster than large diameter trees.

Sapwood decay can create significant tree hazards in addition to a reduction in economic value. This is particularly true for fire-injured true fir, as surviving trees that develop extensive sapwood decay over the next few years could present hazards to the road system and crews working in burned stands. Previous FHP monitoring of fire-injured trees revealed the failure of 8" to 24" dbh red and white fir, with green crowns, in as little as three years (Figure 5) (Report: SPR-07-05). The rate of failure increased dramatically after the fourth year, especially in conjunction with high winds or heavy snows. This type of post-fire tree failure was observed in the 1999 Bucks Fire (Plumas NF), 2001 Star Fire (Tahoe NF) and the 2000 Storrie Fire (Lassen NF).



Figure 4. Woodboring beetle galleries (holes in sapwood) and blue stain.

Fire-injured tree marking guidelines

The guidelines developed by Region 5 FHP, *Marking guidelines for fire-injured trees in California* (Smith and Cluck 2011) are appropriate for use in the Frog Fire. The following factors should be considered when selecting the probability of mortality(s) for tree removal:

- the need to expedite tree harvest to capture economic value before significant deterioration and degrade occurs
- the potential for high levels of post-fire bark beetle activity in ponderosa pine due to elevated pre-fire bark beetle activity levels within and adjacent to the burned area
- the current extreme to exceptional drought conditions resulting in increased moisture stress on individual trees
- the need to reduce the number of fire-injured trees along roadsides that have a high probability of mortality
- the need to meet post-fire fuels objectives

- the need to meet post-fire wildlife objectives
- the need to meet reforestation objectives

Since the Frog Fire burned later in the growing season, Jeffrey and ponderosa pines had mostly finished needle growth by the time their crowns were scorched. Therefore, the crown scorch guideline for yellow pine (pre-bud break) should be used to mark these species at this time. If tree marking continues next spring/summer, the crown kill guideline for yellow pine (post-bud break) should be used as soon as new growth is clearly visible throughout the crown. The red turpentine beetle guideline is also not recommended until bud-break in June 2016 due to the timing of the fire and cambium sampling is not recommended due to limited increases in guideline accuracy relative to the large amount of time required to perform inspections on individual trees.

The probability of mortality (P_m) often selected for post-fire projects in California is 0.7. A P_m of 0.7 is a relatively conservative guideline in that a land manager can be fairly certain that a tree marked at this level is likely to die within the next 5 years. Marking fire-injured trees at this level has had mixed results as trees that have a P_m of 0.1 to 0.6 are left on the landscape. In some cases, many of these “leave trees” have ended up dying. For some recent fire-salvage projects that have occurred during the current drought, a $P_m=0.7$ has proven too conservative. This has led to the need to conduct additional salvage and roadside hazard projects to meet management objectives.

In order to compensate for the impacts of the current extreme/exceptional drought and high levels of bark beetle activity in expected in fire-injured trees, a more aggressive guideline should be selected to meet management objectives. Current conditions and recent observations of delayed fire-injured tree mortality indicate that selecting a lower probability of mortality threshold is the best way to insure that post-fire management goals are met.

Guideline alternatives:

- 1) *Only mark and remove trees with no green needles* - This will insure that no tree will be removed that may have otherwise survived its fire-injuries. This will also result in a large number of trees remaining on the landscape that will ultimately die from fire-injury and subsequent bark beetle attack. These dead trees may have to be felled and/or removed at a future date, at high cost, to facilitate tree planting, reduce large woody fuel loading and/or mitigate tree hazards.
- 2) *Mark all trees at the $P_m=0.7$ level* - Under more normal precipitation and bark beetle activity this would be a conservative, yet reasonable approach to meet post-fire objectives. Especially if the ability to harvest additional trees as they die (trees that didn't initially meet the mortality threshold) is built into sale contracts. Under the current conditions, this conservative approach is expected to result in nearly the same scenario as Alternative #1, where large numbers of trees will remain on the landscape that will ultimately die from fire-injury and subsequent bark beetle attack.
- 3) *Mark trees at a lower P_m level to compensate for the current extreme/exceptional drought and high level of bark beetle activity* – This alternative is the best approach to address the expected high levels of delayed fire-injured tree mortality. This approach will help capture

the economic value of dead and dying trees in a timely manner without the need for future entries to meet management objectives. Suggested marking guidelines are as follows:

- A Pm of 0.4 for yellow pine, white fir and incense cedar <30" DBH, both on the interior and roadsides. This guideline would help capture most of the post-fire tree mortality within treatment units for this size class category to meet project objectives of capturing economic value, reducing fuel loads, mitigating roadside hazards and reducing the number of harvest entries.
- A Pm of 0.5 for yellow pine, white fir and incense cedar ≥30" DBH along roadsides. The rationale for this guideline is the same as above but giving larger trees more benefit of the doubt while accounting for roadside safety concerns.
- A Pm of 0.7 for yellow pine, white fir and incense cedar ≥30" DBH in the interior. This guideline gives large trees the benefit of the doubt in areas where hazard trees are not a primary concern. This guideline will likely provide significantly more large tree snag habitat through delayed mortality and this should be considered when accounting for minimum snag requirements.

Hazard tree marking guidelines

Region 5 FHP has recently developed new hazard tree guidelines (Angwin et al 2012). These guidelines more clearly define failure and target potential to help land managers make more informed decisions for hazard tree abatement projects. In using these guidelines for roadside hazards, the district will need to decide which trees need to be removed based on the failure potential rating of any defect(s) found (including fire-injuries) and the "Exposure Duration" (Long, Short or Intermittent With High Frequency), which reflects such factors as road maintenance level, traffic volume, and degree to which people stop and congregate.

Please keep in mind that the FHP hazard tree and fire-injured tree guidelines are addressing different subjects. The fire-injured tree marking guidelines are predicting tree mortality, not failure potential. The hazard tree guidelines predict tree failure potential, not tree mortality. Both can be used along roadsides to abate existing tree hazards due to defect and remove trees that are likely to die from fire injuries and pose a hazard in the near future. Both guidelines have been provided to the Big Valley/Doublehead Ranger District.

Treatment of cut stumps to prevent Heterobasidion root disease

Fresh cut stumps of fire-injured trees can provide entry courts for Heterobasidion root disease (*Heterobasidion occidentale* and *H. irregulare*). Stumps of trees killed by fire that have been dead less than 18 months should also be considered susceptible. Therefore, it is recommended that a registered borate compound be applied to all freshly cut conifer stumps >14" dbh in order to reduce the chance of new Heterobasidion root disease centers being created through harvest activity. However, treatment of stumps may not be beneficial in high severity harvest areas where no green trees remain.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431.

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